

### **Example 44-3.2**

Given:     Design Speed = 90 km/h  
             $G_1 = -1.5\%$   
             $G_2 = +2.0\%$   
             $A = 3.5\%$   
            PVI Station = 4 + 910  
            PVI elevation = 195.710

Problem:   At Station 4 + 860, the new highway must pass under the center of an existing railroad which is at elevation 203.910 at the highway centerline. The railroad bridge that will be constructed over the highway will be 1.2 m in depth, 6.0 m in width and at right angles to the highway. What would be the length of the vertical curve that would provide a 5.05-m clearance under the railroad bridge?

Solution:

1. Sketch the problem with known information.

**Example 44-3.2** (continued)

2. Determine the station where the minimum 5.05 m vertical clearance will occur (Point P):

From inspection of the sketch, the critical location is on the left side of the railroad bridge. The critical station is:

$$STA. P = BRIDGE CENTERLINE STATION - \frac{1}{2}(BRIDGE WIDTH)$$

$$STA. P = STA. 4 + 860 - \frac{1}{2}(6 m)$$

$$STA. P = STA. 4 + 857$$

3. Determine the elevation of Point P:

$$ELEV. P = ELEV. TOP RAILROAD BRIDGE - BRIDGE DEPTH - CLEARANCE$$

$$ELEV. P = 203.910 m - 1.200 m - 5.050 m$$

$$ELEV. P = 197.660 m$$

4. Determine distance, D, from Point P to PVI:

$$D = STA. PVI - STA. P$$

$$= (4 + 910) - (4 + 857) = 53 m$$

5. Determine the tangent elevation at Point P:

$$ELEV. TANGENT AT P = ELEV. PVI - G_1 \left( \frac{D}{100} \right)$$

$$= 195.710 m - (-1.5) \left( \frac{53}{100} \right)$$

$$= 196.505 m$$

6. Determine the vertical curve correction (Z) at Point P:

$$Z = ELEV. ON CURVE - ELEV. OF TANGENT$$

$$= 197.660 - 196.505$$

$$= 1.155 m$$

7. Solve for X using Step #4 from Figure 44-3I:

$$X = \frac{400 Z \pm \sqrt{160,000 Z^2 + 1600 ADZ}}{2A}$$

$$X = \frac{400 (1.155) \pm \sqrt{(160,000)(1.155)^2 + 1600(3.5)(53)(1.155)}}{2(3.5)}$$

$$X = 172.55 m \quad \text{AND} \quad X = -40.55 m \quad (\text{Disregard})$$

8. Using Step #3 from Figure 44-3I, solve for L:

$$L = 2(X + D)$$

$$L = 2(172.55 + 53)$$

$$L = 451.10 \text{ m}$$

9. Determine if the solution meets the stopping sight distance for the 90 km/h design speed. From Figure 44-3C, the K-value is 38.

The algebraic difference in grades:

$$A = G_2 - G_1 = (+2.0) - (-1.5) = 3.5$$

From Equation 44-3.2, the minimum length of vertical curve which meets the stopping sight distance:

$$L = KA$$

$$= 38 (3.5)$$

$$= 133 \text{ m}$$

L of 451.10 m exceeds 133 m, therefore the desirable stopping sight distance is satisfactory.

### **VERTICAL CURVE COMPUTATIONS (Example 44.3-2)**

**Figure 44-3J**